LATE CAINOZOIC SEDIMENTATION IN NORTHERN SPENCER GULF, SOUTH AUSTRALIA

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SUMMARY

Because of its unique position, fronting the Southern Ocean, the southern margin of the Australian continent provides many situations where the relationships between superposed or juxtaposed marine, transitional and continental deposits and associated land surfaces can be worked out. One of these situations in the South Australian portion of the southern continental margin is examined.

Sediments of late Cainozoic age were deposited in a compound rift which now contains Spencer and St. Vincent Gulfs and Lake Torrens.

Two sequences of clay, gravel and sand appear in a bore at the head of Spencer Gulf: a lower sequence at least 300 feet thick, which is correlated with sediments of known Tertiary age in the St. Vincents Basin, and an upper sequence laid down in a piedmont-valley flat environment, which is correlated with the "Pleistocene mottled clays" near Adelaide. Above the upper piedmont-valley flat deposits is a sequence of *Anadara*-bearing shelly limestone, clay and sand laid down in littoral and marine gulf environments.

It is suggested that a strong regression of the sea occurred after deposition of the *Anadara*-bearing limestone and that one of the features marking the regression is a lime-cemented crust on the shelly limestone, which can be traced shoreward to a limy crust in gravelly soil. The soil crust, or kunkar, is tentatively equated with the kunkar in Bakara soil of ?late Pleistocene age in the Murray Basin.

Quaternary events are reconstructed and related to soil and landscape development. Two marine ingressions and two regressions are inferred from vertical changes in lithology and from littoral deposits marking earlier positions of the strandline.

INTRODUCTION

The southern margin of the Australian continent spans 36 degrees of longitude or about 2,400 miles measured along the 35th parallel. Much of Late Cainozoic geological history in the Southern Hemisphere is recorded in the sedimentary basins, or on the massifs between the basins, by weathered rocks, soils, sediments and landforms. There are many situations near the southern coast where correlation between marine deposits of the ocean basins, transitional and continental deposits, and land surfaces can be worked out. Shifts in the strand and fluctuations in environment consequent upon the profound climatic changes of the Quaternary are recorded here also.

Many of the marine, transitional and continental deposits, together with their related land surfaces are superposed or juxtaposed in the South Australian portion of the continental margin.

The sediments described in this paper were deposited in a compound rift which occupied much the same area as the present Spencer and St. Vincent Gulfs and the low-lying tract extending northwards through Lake Torrens. (see Locality Map—Fig. 1). Lithofacies and structural details set out in bore logs and on Geological Survey maps clearly show that the rift, a second order geomorphic feature, was well developed in early Tertiary Time.

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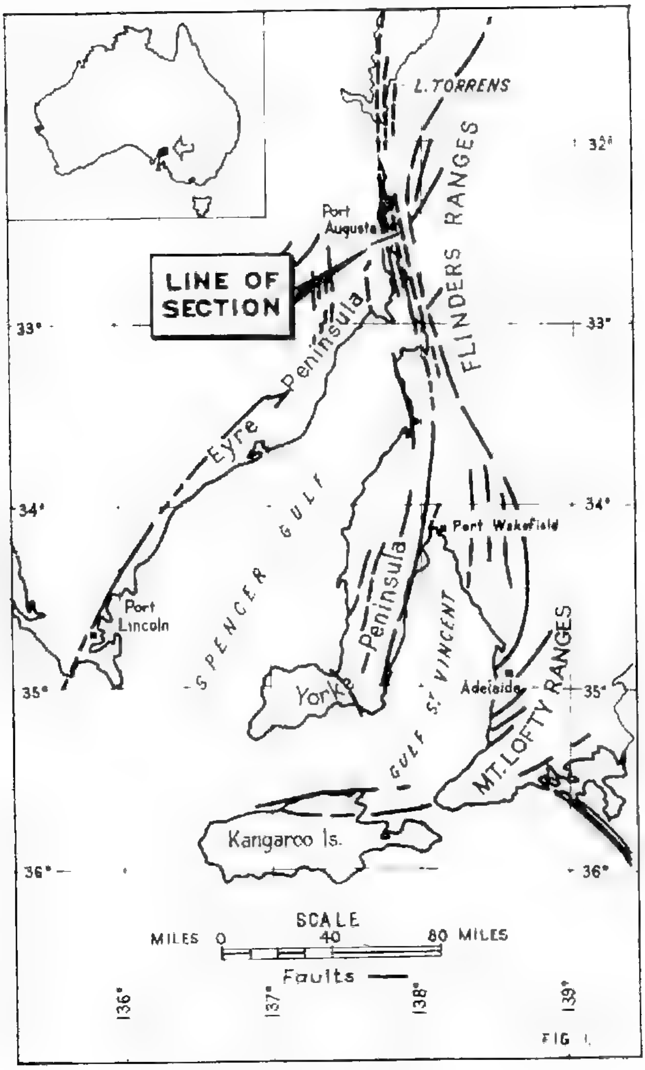

Fig. 1. Locality Map.

TECTONISM

The horst and grabens and associated faults within and bounding the rift have been discussed in a general way by Fenner, 1930, and others, and in some detail with reference to specific areas by Miles, 1952 and Campana, 1955. The more prominent faults are shown on Fig. 1. after Johns, R. K. (1964). Thomson (1965) stresses the oscillation of fault blocks as an important tectonic feature as early as the Precambrian. Early marginal faults were covered by later Tertiary deposits. Major faulting ceased at the end of the Pliocene, although displacement on some faults continued into the Pleistocene. Epeirogenic uplift of at least 200 feet since mid-Tertiary time can be demonstrated for the area as a whole, with uplift increasing in the Mt. Lofty Ranges (amounting to 600 feet in the Mt. Lofty Ranges in Late Pliocene times, according to Glaessner and Wade in Glaessner, M. F. and Parkin, L. W., 1958).

PROVENANCE

Much of the terrigenous material in Tertiary and Quaternary sedimentary sequences in Spencer Gulf is derived from older Precambrian metamorphics and younger Precambrian to Lower Palaeozoic sediments of the Mt. Lofty-Flinders Ranges and Yorke and Eyre Peninsula massifs. At the head of Spencer Gulf, coarser clastics in Quaternary deposits can be traced to known rock units of the adjoining ranges. East of the section, in the Flinders Ranges, peaks rise to 3,174 feet above sea level at Mt. Brown. West of the section, the Arcoona Plateau (Johns, op. cit.) has a general elevation of about 600 feet with monadnocks rising to over 1,000 feet above sea level.

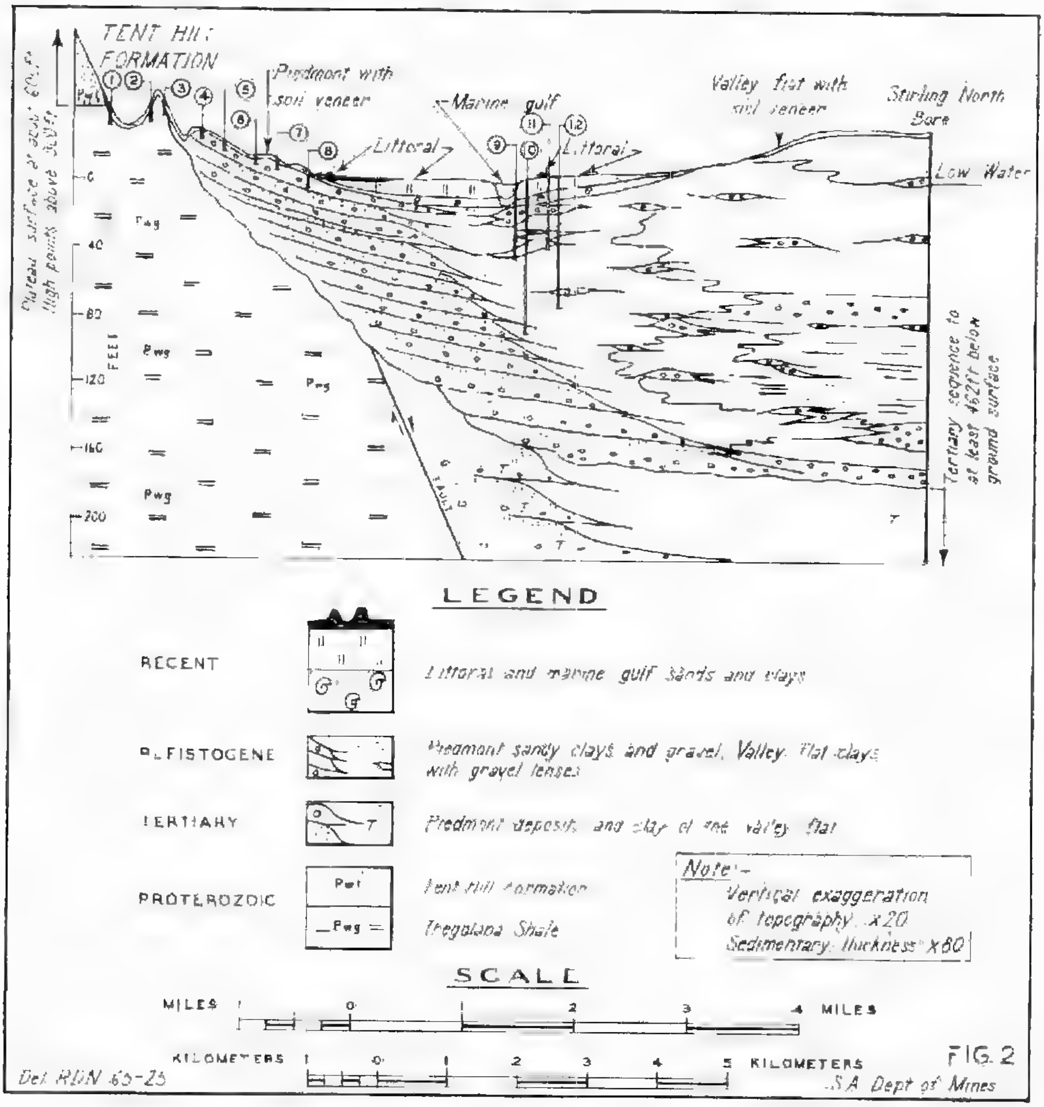
TENT HILL FORMATION
Plateau surface at about 600 ft high points above 800 ft
Pwt
①②③④⑤⑥⑦⑧⑨⑩⑪⑫
Piedmont with soil veneer
Marine gulf
Littoral
Littoral
Valley flat with soil veneer
Stirling North Bore
Low Water
0
40
80
120
160
200
FEET
Pwg
Pwg
Pwg
Pwg
FAULT
T
T
T
Tertiary sequence to at least 462 ft below ground surface
LEGEND
RECENT
Littoral and marine gulf sands and clays
PLEISTOCENE
Piedmont sandy clays and gravel. Valley flat clays with gravel lenses
TERTIARY
Piedmont deposits and clay of the valley flat
PROTEROZOIC
Pwt
Tent Hill Formation
Pwg
Tregolana Shale
Note:-
Vertical exaggeration of topography x20
Sedimentary thickness x80
SCALE
MILES 1 0 1 2 3 4 MILES
KILOMETERS 1 0 1 2 3 4 5 KILOMETERS
FIG. 2
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Fig. 2. Diagrammatic structure section, Spencer Gulf, South Australia. For details from Bore 1 to Bore 12 see Fig. 3. Note that the shell-bearing sediments shown in the upper block in the legend are taken to be Late Pleistocene in this report.

SEDIMENTS AND TIME BOUNDARIES

At least 462 feet of ?non-marine sediment are known from an abandoned bore at the head of Spencer Gulf near Port Augusta (Hullett, 1882). The materials described can be divided into two sequences; a distinctive 150-200 feet thick upper sequence of clay with sand and gravel lenses and with limy B horizons of fossil soils in a piedmont-valley flat environment, and a lower sequence of white, blue, yellow and black[1] clays, gravels and sands, at least 300 feet thick, which contains lignitic clays and carbonaceous sands (see Fig. 2). The upper sequence is correlated with the "Pleistocene mottled clays"[2] near Adelaide on the basis of lithology, environment and occurrence within connected morphostratigraphic units as defined in Frye and Willman (1962). The lower sequence is correlated with sediments of known Tertiary age in the adjoining St. Vincents Basin on the basis of colour, lithology and carbonaceous material.

A thin sequence of littoral and marine gulf deposits overlies the upper piedmont-valley flat clay with sand and gravel lenses. The sequence contains shelly limestone with *Anadara trapezia*, silty clay with plant fibre and shelly sands of the beach ridges and shallow channels. The top of the shelly limestone is strongly lime-cemented and this feature can be traced shorewards through littoral shelly granule and pebble conglomerates to a limy crust in gravelly soil (see Fig. 3).

The Pliocene-Pleistocene boundary in this area may be deeper than the base of the piedmont-valley flat deposits. This is suggested by comparison with similar sequences near Adelaide in the St. Vincent Basin. Here Ludbrook, 1963, may be interpreted to show that if " . . . the extinction of warm-water Yatalan fauna" represents "the onset of colder conditions at the end of the Pliocene", then a sandy sequence 150 feet thick occurs between the marine Dry Creek Sands of Pliocene age and the overlying piedmont-valley flat deposits of Pleistocene age ("Pleistocene mottled clays").

The Pleistocene-Recent boundary has not been precisely determined in the section area, but the lime-cemented top of the *Anadara*-bearing limestone is now thought to have formed at the same time as a calcareous crust ("Kunkar") which is a fossil 'B' horizon in adjacent gravelly and brown soil. The kunkar in this area may be equivalent to the kunkar in Bakara Soil (Firman, 1964), which is thought to be of late Pleistocene age. Materials stratigraphically above the crust or lime-cemented top of the *Anadara*-bearing beds are taken as Recent in this report. Radiocarbon dating, proposed for materials from this area, may help to place the time boundary and will also provide important information on the time of strandline movements in Spencer Gulf.

QUATERNARY EVENTS

Quaternary geological events begin with deposition of clays, sands and gravels in the rift, coarser clastics of the piedmont facies on the margin near the massifs and valley flat deposits in the rift centre.[3] The topographic profile can be reconstructed to show that the upper surface of this sequence was as much as 180 feet above the present floor of the gulf. That is, about 180 feet of the sequence has been removed by erosion prior to marine ingression. The Gulf now lies west of the old rift centre (Fig. 2). The asymmetry may be due, in part

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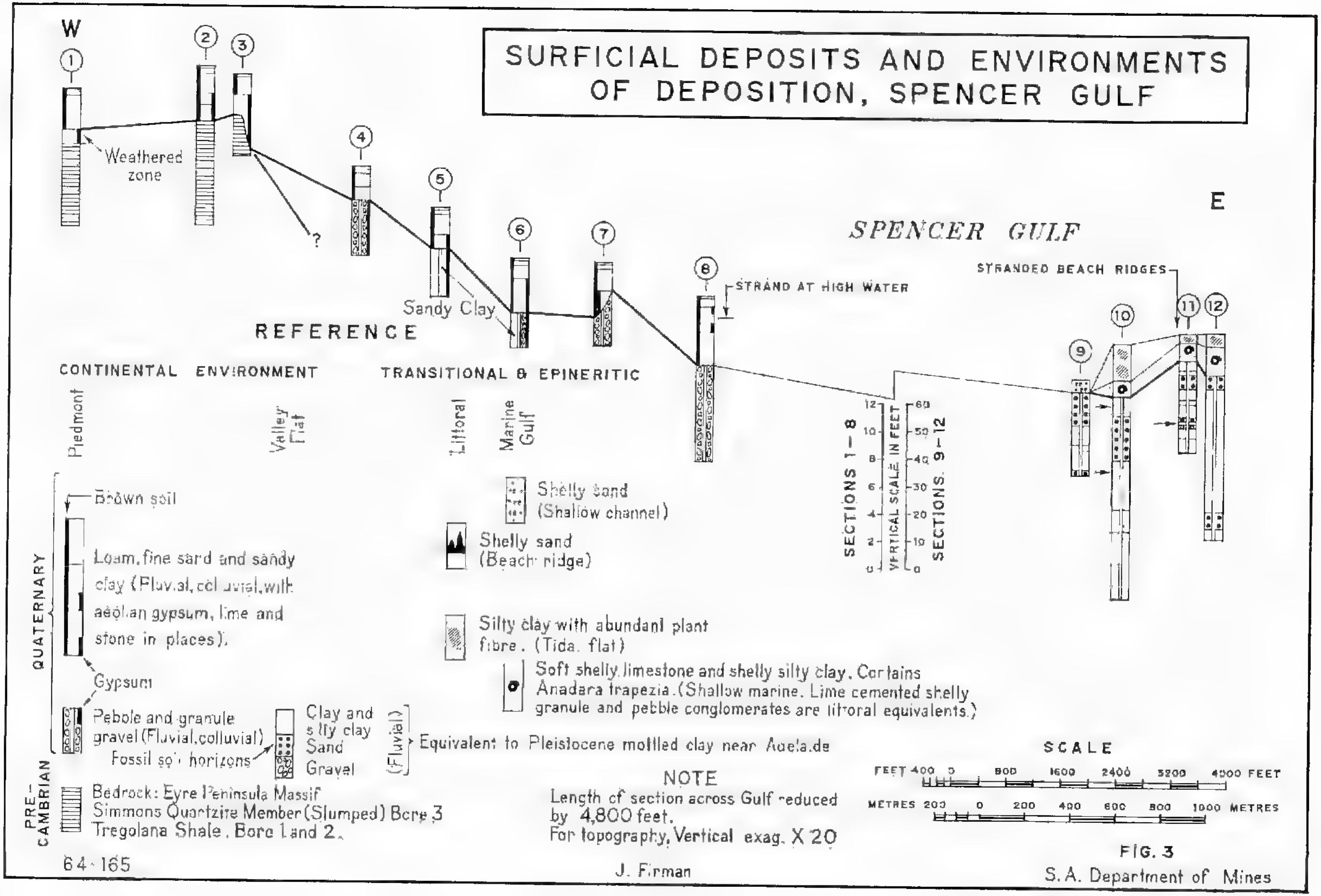
[1] Colours from original log.

[2] Informal name in common use in South Australia.

[3] The sedimentary sequence here described is much the same as the sequence near Adelaide in the St. Vincent Basin (see Firman, 1963).



SURFICIAL DEPOSITS AND ENVIRONMENTS OF DEPOSITION, SPENCER GULF

W
E
1
2
3
4
5
6
7
8
9
10
11
12
Weathered zone
?
Sandy Clay
SPENCER GULF
STRAND AT HIGH WATER
STRANDED BEACH RIDGES
REFERENCE
CONTINENTAL ENVIRONMENT
TRANSITIONAL & EPINERITIC
Piedmont
Valley Flat
Littoral
Marine Gulf
SECTIONS 1 – 8
VERTICAL SCALE IN FEET
SECTIONS 9 – 12
12
10
8
6
4
2
0
60
50
40
30
20
10
0
QUATERNARY
PRE-CAMBRIAN
Brown soil
Loam, fine sand and sandy clay (Fluvial, colluvial, with aeolian gypsum, lime and stone in places).
Gypsum
Pebble and granule gravel (Fluvial, colluvial)
Fossil soil horizons
Clay and silty clay
Sand
Gravel
(Fluvial)
Equivalent to Pleistocene mottled clay near Adelaide
Bedrock: Eyre Peninsula Massif
Simmons Quartzite Member (Slumped) Bore 3
Tregolana Shale. Bore 1 and 2.
Shelly sand (Shallow channel)
Shelly sand (Beach ridge)
Silty clay with abundant plant fibre. (Tidal flat)
Soft shelly limestone and shelly silty clay. Contains Anadara trapezia. (Shallow marine. Lime cemented shelly granule and pebble conglomerates are littoral equivalents.)
SCALE
FEET 400 0 800 1600 2400 3200 4000 FEET
METRES 200 0 200 400 600 800 1000 METRES

NOTE

Length of section across Gulf reduced by 4,800 feet.
For topography, Vertical exag. X 20

64-165

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FIG. 3

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to westward tilting of the fault block below the gulf. A reconstruction of topography immediately prior to the ingression and deposition of the *Anadara*-bearing beds on the gulf floor can be made by connecting the tops of marine cliffs near the present strand. At this time the upper surface of the piedmont-valley flat deposits was 25 feet above the present floor of the gulf (about 13 feet above L.W.O.S.T.). A feature of interest at the present top of the unit is the presence of abundant massive crystalline gypsum indicating that here, as elsewhere in Australia during this part of Quaternary time, sulphates were being deposited in drying playas.

Marine ingression, the first such event recorded here in the Tertiary-Quaternary sequence, is shown by soft shelly limestone and shelly silty clay ("marl") containing *Anadara trapezia*. Outcrops of the littoral equivalent of this unit are found well above the high tide mark and inland behind ridges of beach gravel that barred old stream channels during this early high strand of the sea. The vertical position of materials in this area suggests a stand about 10 feet above L.W.O.S.T., but similar materials elsewhere are found higher in the landscape (up to 25 feet above L.W.O.S.T. near Pt. Wakefield). Stranded marine cliffs may have been first formed at this time.

Regression led to strong incision of streams, with erosion of the upper clays and gravels near the ranges, and a first accession of lime here at the base of the brown soil profile. The top of the exposed *Anadara*-bearing limestone was cemented by lime. Similar lime-cemented materials are known from the floor of Gulf St. Vincent 70 feet below sea-level, suggesting that this was a major regression. The later development of the brown soil is due to sedimentary layering and soil differentiation (see Fig. 3).

A return of the sea, bringing a tidal flat environment to the Gulf margin, led to deposition of silty clay with abundant plant fibres. This early phase of the ingression was succeeded by a high stand of the sea of perhaps five feet, which is marked elsewhere along the gulf margins by shell beds.

Coarse shelly sand of the stranded beach ridges marks a later regression. The formation of a deep off-shore channel, as shown on the east side of the section, also marks a low stand of the sea, perhaps slightly below modern sea level. Similar features are well developed at other places along the South Australian coast, near Port MacDonnell for example, where they connect an older and higher littoral environment with the modern coast. In some places surface drainage was restricted and evaporation reached the stage of halite precipitation.

Modern streams have breached the old gravel bars of the 10 ft. sea level Modern deposits are alluvial sands and gravels of the present stream courses dune sands formed by aeolian working of stranded beach ridges, granule and pebble beds forming beaches in the present littoral zone, and the shelly sands and silts of the gulf floor and the off-shore channels.

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